

Observations on the Respiratory Action of the Carnivorous Water-Beetles (Dytiscidæ). By D. SHARP, Esq., M.B. (Communicated by H. W. BATES, Esq., F.L.S. &c.)

[Read November 2, 1876.]

THE observations here recorded were commenced by me some time ago, to see if I could get any insight into the peculiarities of the aeration or respiration of the carnivorous Water-beetles, or Dytiscidæ, at a time when I was hoping I should be able to make some inquiries about the function of respiration in the Insecta generally. I very soon found, however, that the subject was so vast, and the difficulties of making accurate minute investigations as to one of the functions of creatures so small as the insects I could procure were so great, that I abandoned my intention. But as the observations I made, though of a desultory character, are not without suggestiveness on certain points, I have thought it worth while they should be placed on record. I think that if such observations were carried out very much more fully and systematically, they would serve as material to enable us to fill up some of the vast gaps which exist in our knowledge of the physiology of this highly organized class of the Invertebrata.

The two most interesting species of all those I observed are undoubtedly *Pelobius Hermannii* and *Hydrovatus clypealis**. These species are, in their structure, much less highly developed for moving through the water than our other indigenous Water-beetles, and are, in my opinion, to be considered (together with the North-American Amphizoa) the most rudimentary or primitive of the existing forms of Dytiscidæ. Their habits quite accord with their structural peculiarities. *Pelobius Hermannii*, though it is a powerful swimmer, moves its limbs in such a rapid manner that it must be incapable of any long-sustained efforts—and, in point of fact, passes its life, in the perfect state, concealed in soft mud, from which it suddenly rises to the surface to take air, and descends again to its concealment with great rapidity. According to my observations, the time it is concealed bears to the time it is exposed for breathing a ratio of 375 to 1; whereas in one of

* I have much pleasure here in acknowledging the kindness of Henry Moncreaff, Esq., who procured and forwarded to me living individuals of these two species, neither of which occurs in Scotland.

the highly developed forms of the family, *Dytiscus marginalis*, the corresponding ratio is about 12 to 1. The amount of food the *Pelobius* takes is surprisingly small; and I have kept the specimens for weeks without giving them any food, and without, I believe, their obtaining any in the water in which they were placed; but they did not appear to suffer from the deprivation. These habits afford a striking example of the truth of Herbert Spencer's generalization, that the grade of development of an organism bears a direct proportion to its activity.

Hydrovatus clypealis is a species that moves extremely little and slowly; and its motion is rather that of running or gliding than of swimming. It glides over the surface at the bottom of the water, and climbs up weeds for the purpose of breathing—and was observed on one occasion, instead of ascending to the surface, to make use of a bubble of gas adhering to a plant; the gas, I suppose, would probably be pure oxygen.

Hyphydrus ovatus is one of the most specialized forms of the Dytiscidæ, but of a form which is of a low type compared with others of the family; and its habits appear to correspond with its structural peculiarities.

The species of *Hydroporus* were only very insufficiently observed; but it would appear from such observations as were made that great diversity will probably be found to exist in the habits of the extremely numerous species of this genus, and that such observations may assist in the difficult task of classifying in a natural manner the species of this extensive genus.

The observations on *Dytiscus marginalis* suggest that the male of this species is more active and breathes more frequently than the female—a fact which quite agrees with the structural peculiarities of the species; for the male is rather larger than the female, and has the swimming-legs very much more developed. This difference between the activity of the sexes is probably general throughout the family. I think it possible that further observations with reference to this fact might throw some light on what has been hitherto an insoluble puzzle to entomologists, viz. the existence in several species of *Dytiscus* of two forms of the female, one of these two forms resembling the male in some of its peculiarities. The genus *Dytiscus* is remarkable in the family, from the great development of the posterior breathing-orifices; but I have failed as yet to obtain any clue to the relation of this structural peculiarity with the habits of the species.

The observations on the two species of *Acilius* appear to show a great difference in habits between the two closely allied species observed; but I think that further and more extensive observations would probably greatly reduce this discrepancy; for I believe that the time of day, the season of the year, the condition of sexual activity, the sex of the individual, the process of digestion, and the condition of hunger, all modify the activity of the Dytiscidæ.

It appears probable that most of the species are much more active by night than by day.

I regret very much that I have not been able to make any observations on *Cybister Roeselii*; for I consider the genus *Cybister* to be, all points considered, the most highly developed form of the family. It is known that some of the species of *Cybister* are enormous devourers of animal food; and I think it probable that observations would show these to be the most active by far of all the members of the family. No species of the genus occurs in Britain; so that it is not likely I shall be able myself to make observations on any of the species.

I have reduced most of the observations made, by a system of averages, so as to allow of their being easily compared with one another, and have given the averages obtained of most of the species.

I. PELOBIUS HERMANNI.

No. 1. Breathing-observation made on four individuals, two ♂, two ♀, August 29th, 1875.—These specimens were completely concealed in soft mud; this they left for breathing, rose rapidly to the surface, and, after breathing, descended with great rapidity and buried themselves in the mud.

Observation commenced at 11.46 A.M. :—

11.57, only very short time up.	12.36 remained up 3 secs.
12.9 remained up 2 secs.	12.38½ " 13 "
12.10½ " 4 "	12.42 " 5 "
12.17½ " 3 "	12.50 " 3 "
12.26 " 1 sec.	12.51 " 3 "

Observation ceased at 1 P.M. Thus each individual spent only 10 seconds out of 74 minutes at the surface in breathing.

No. 2. Aug. 29th, 1875.—The same four specimens were under surveillance, commencing at 3.40 P.M. and ceasing at 4.30 P.M. :—

3.44, remaining up 3 secs.	4.11, remaining up 10 secs.
3.56 " 4 "	4.16 " 6 "
4.10 " 2 "	4.21 " 12 "

Thus each individual passed 9 seconds out of 50 minutes in air-exposure.

No. 3. September 5th, 1875.—Observations on four beetles, two males and two females. Watching commenced at 3.22 P.M. when the following ascents were noticed:—

3.23, remained up 3 secs.	4.12, remained up 4 secs.
3.28 " 2 "	4.36 " 3 "
3.37 " 4 "	4.47 " 5 "
3.38 " 2 "	4.56 " 4 "
3.51 " 5 "	4.58 " 20 "
3.53 " 14 "	5.2, observation ceased.

The beetles were entirely concealed under the mud, which they suddenly left and directly returned to.

No. 4. Same date and specimens as in preceding No. 3.—Began to notice their movements at 7.42 P.M., by lamplight, daylight having then gone:—

7.48, remained up 2 secs.	8.22, remained up 2 secs.
7.48 " 4 "	8.24 " 5 "
7.50 " 5 "	8.27 " 15 "
7.58 " 4 "	8.29 " 6 "
8. 2 " 3 "	8.30 " 4 "
8. 5 " 12 "	8.41 " 4 "
8. 9 " 2 "	8.42, observation ceased.

That which came up at 7.50 swam round the vase. At 8.7, a specimen left the mud and swam round the vase, but did not rise to the surface. That which arose at 8.22 and remained up 2 seconds made an excursion. These beetles generally kept themselves concealed in the mud, but were not quite so inactive as in the preceding set of observations.

No. 5. Sept. 19.—Kept watch on a female from 3.36 P.M. until 4.36 P.M. It remained buried in the mud all the while, never being seen.

No. 6. Sept. 20th.—Same female as in last, and in the same vase. By lamplight, 8.42 P.M., proceeded to keep a close lookout. The beetle rose at 9.1, and disappeared almost instantaneously.

neously. At 9.14 and again at 9.28 it acted in a similar way, while at 9.42 I myself stopped short observing. The whole operation of rising, opening elytra at surface, diving and burying itself again in the mud was performed in each case with such rapidity as to yield merely sufficient time for its recognition.

No. 7. Oct. 17th.—This observation, on a female, commenced at 2.1 P.M. It then lay concealed in the mud, but rose at 2.18, resting for about 2 seconds for the purpose of aeration. My observation ceased at 3.4 P.M.

No. 8. Renewed observation at 4.25 P.M., and kept watch until 5.25. During this hour the beetle remained concealed in the mud and was not visible.

No. 9. Same night at 9.7, by lamplight.—The insect was concealed in the mud and did not rise whilst notice was kept, viz. until 10.7 P.M.

The following tabular statement gives the numerical results of the foregoing series of observations.

Observations.	Number of specimens.	Minutes of observation.	Minutes × specimens. =	Ascents.	Seconds at surface.
No. 1...	4	63	252	10	37
„ 2...	4	50	200	6	37
„ 3...	4	100	400	11	66
„ 4...	4	60	240	13	78
„ 5...	1	60	60		
„ 6...	1	60	60	3	3
„ 7...	1	63	63	1	2
„ 8...	1	60	60		
„ 9...	1	60	60		
Totals..	21	576	1395	44	223

Summary.—From what has been stated, it may be inferred that *Pelobius Hermannii* rises for the purpose of aeration on the average once in every $21\frac{3}{4}$ minutes, but often goes one hour without ascending to the air. In these observations the time it remained at the surface to perform aeration or respiration varied from a single second, or less, to 20 seconds, and was, on the average, 5 seconds; and the time it was exposed bore to the time it was concealed a ratio of 1 : 375. The observations also suggest

that probably the female is even more sedentary than the male, and also that perhaps it is more active after dark than during daylight.

The creature's natural habit appears to be almost constant concealment in the soft mud at the bottom of the water; from this it rises to breathe and descends into the mud with great rapidity.

II. HYDROVATUS CLYPEALIS.

No. 1. Aug. 29th, 1875.—This observation commenced at 3.15 P.M. The individual, a female, at first was not to be seen, but at about 4.45 was noticed to be walking on the sand at the bottom of the water; and at 4.50 it ascended towards the surface by crawling up the stem of a plant; but before reaching the surface it found a bubble of gas adhering to the plant, when it turned round and backed its posterior extremity into the bubble. The observation ceased at 4.55, when it was still in this position. If this observation be correct, the insect was $1\frac{1}{2}$ hour without breathing; but it is possible that it may have breathed other gas-bubbles on the plant without being noticed. I do not think, however, such was the case.

No. 2. Sept. 12th.—From 4.5 P.M. till 5.45 P.M. (namely, in all, 100 minutes) kept watch on a female specimen of *H. clypealis*, which was concealed under a small stone, and did not emerge during this interval of time.

No. 3. Same date.—At 9.19 P.M., by lamplight, began watching the above-mentioned ♀. At 9.24 it was gliding about the sand, and rose for a scarcely appreciable instant, did not breathe, afterwards glided about, and rose at 9.27 for about 3 seconds to take in air; also at 9.51 for about 3 seconds. The observation ceased at 10.9.

It is possible that the artificial light interfered with its movements; it was observed to pass over the surface of the sand with a comparatively slow motion which appeared to be running rather than swimming, and availed itself of the side of the glass or some object rising to the surface to guide it up; it followed up the course of such object with the running motion above alluded to.

No. 4. Sept. 26th.—No sight of the beetle, which lay concealed under a small stone. Observation from 1.31 P.M. for an hour.

No. 5. Same date.—Observation commenced at 9.11 P.M., by lamplight. At 9.50 it came out from under a stone, crawled up the

plants to the surface, breathed for 15 seconds, then descended and remained quiet on the sand, but not concealed. At 9.56 again rose and breathed for 2 secs., then descended and concealed itself, rose again at 10.7 and breathed for 5 secs., after which it gently moved about. The observation ceased at 10.11 P.M.

The data resultant from these 5 observations are as subjoined:—

Obs.	No. of spec.	Minutes of ob.	Ascents	Aerial exposure.
1	1	100	1	10 min.
2	1	100	—	—
3	1	50	3	6 secs.
4	1	60	—	—
5	1	60	3	22 secs.

Summary.—A female of *Hydrovatus clypealis*, as the result of five observations extending over a period of 370 minutes, was only observed to breathe seven times, or an average of about once in 53 minutes; it has been observed to be 100 minutes without breathing, while, on the other hand, it has been observed that there is sometimes only an interval of 6 minutes between two respirations; the period it remained breathing at the surface varies from 1 sec. or less to 15 secs.

It is probable that the species is more active at night than during the day.

This species appears sometimes to take advantage of a bubble of gas attached to a plant for its breathing, and has been observed remaining for 10 minutes in a position enabling it to breathe such a bubble. It walks or glides rapidly over the surface at the bottom of the water rather than swims, and likes to rise by guiding itself up the stem of a plant; when it swims freely through the water it is only for a short distance.

III. HYPHYDRUS OVATUS.

No. 1. Aug. 29th, 1875.—The female example I here watched was quite quiescent at edge of stone with bubble of gas adhering to its extremity; observation commenced at 3.15 P.M. At 3.52 it moved and came up, but almost instantly descended and renewed its quiescent position; it again ascended at 4.35, and remained up 6 seconds. Observation ceased at 4.53. Thus only about 6 seconds out of 98 minutes were passed in breathing at the surface; the bubble of gas was always present.

No. 2. Sept. 12th.—At 4.5 P.M. took my station at the side of the vase containing the female *H. ovatus*. It appeared at the surface at

4.12, resting there 15 seconds.		4.45, resting there 3 seconds.
4.21 " " 25 "		5.17 " " 10 "

Observation ceased at 5.45 P.M. The insect carries a bubble at tip of body, which, by movements of the segments, is sometimes retracted under elytra and again exerted without being detached.

No. 3. Commenced observation same night at 9.19 by artificial light. The beetle rose at

9.31, remained up 1 sec.		9.51, remained up 3 seconds.
3.38 " " 20 "		9.57 " " 20 "
* {		9.58 " " — †
		9.44 " " 15 "
		9.45 " " 12 "
		10. 3 " " 10 seconds.
		10. 9, observation ceased.
9.45 " " 8 "		
9.45 " " 5 "		
9.45 " " 12 "		

No. 4. Sept. 26th.—I watched for one hour from 1.31 P.M., but the female in question did not issue from her hiding-place.

No. 5.—9 P.M. by lamplight. Beetle concealed, and did not emerge till 10.2. It then rose to the surface for the purpose of aeration for 3 seconds, and rapidly repeated the process, thus:—

10.2, at surface 3 seconds.		10. 7, at surface an instant.
10.3 " 5 "		10. 8 " "
10.3 " 4 "		10. 9 " "
10.3 " 5 "		10. 9 " 10 seconds.
10.5 " 3 "		10.11, observation ended.

It is probable that its aeratory process was considerably interrupted by the disturbance of the artificial light; and hence the above rapid ascents and descents.

* Within the time mentioned in the bracket the *Hyphydrus* descended for an instant—that is, darted down and up again.

† When it rose to the surface at the hour specified, it remained there motionless for a minute or more, but did not then seem to perform aeration. I presume that the insect was incommoded by the artificial light.

Obs.	Spec.	Minutes of observ.	Ascents.	Seconds at surface.
1.	1	98	2	6
2.	1	100	4	53
3.	1	50	11	106
4.	1	60	—	—
5.	1	60	9	33
	—	—	—	—
Totals...	5	368	26	198

Summary.—*Hyphydrus ovatus*, female, conceals itself beneath stone or weed; it rises to breathe on the average once in $14\frac{1}{8}$ minutes, but has been observed to be one hour without breathing; the time it remains at surface varies from an instant to 25 seconds, and is to the time it is concealed in the ratio of 1 : 111.5.

This species is probably more active at night than during the day. It is a rapid and energetic swimmer.

IV. HYDROPORUS INÆQUALIS.

No. 1. Oct. 10th, 1875.—Observation commenced at 3.41 P.M., the beetle concealed. It, however, rose at 4.10, and remained under atmospheric influence for 5 seconds. Again, 4.39, for 2 seconds; the observation closed at 4.41 P.M.

No. 2. Same evening, 9.14 P.M., by lamplight, *H. inæqualis* being then hidden; but it rose to the surface at 9.27, remaining 5 seconds, and again at 10.8 for the interval of 5 seconds. At 10.14 left off watching.

Obs.	Spec.	Minutes of observ.	Ascents.	Seconds at surface.
1.	1	60	2	10
2.	1	60	2	10
	—	—	—	—
Totals	2	120	4	20

Summary.—Only two observations made, from which it appears that this insect rises once in 30 minutes, and remains at surface about 5 seconds, and the time it is exposed bears to the time it is concealed a ratio of 1 : 360.

V. HYDROPORUS PICTUS.

No. 1. August 29th, 1875.—Obs. commenced 3.15 P.M. The beetle was then quiescent under the edge of a stone; at 3.46 came up to breathe, but rapidly descended and became quiescent.

Again ascended at 4.43, but only remained for about 2 seconds. Observation ceased at 4.53.

No. 2. Sept. 12.—Began to watch at 4.5 P.M. At 4.8 the *H. pictus* rose to the surface for an instant only, but did not do so again, although close attention was given until 5.45 P.M.

No. 3. The same night.—At 9.19 P.M., waited for ten minutes before an ascent was witnessed. The journeys for air succeeded as follows:—

Rose at 9. 2 for 1 second.	Rose at 9.54 for an instant.
„ 9.37 „ 2 seconds.	„ 10. 4 for 1 second.
„ 9.45 „ 1 second.	10. 9, obs. ceased.

These observations were made by lamplight. It is possible the insect was incommoded by the light; it was less quiescent than in the afternoon, making short excursions about the water when it came for breath to surface.

Movements much quicker than those of *Hydrovatus*.

No. 4. Sept. 26th.—When first attention was drawn, viz. at 1.31 P.M., the beetle was under cover. It rose, however, to perform aeration at 2.3 P.M. for 1 second, then it descended and lay concealed as long as the observation lasted, up to 2.31 P.M.

No. 5. Same night.—At 9.11 proceeded to watch by lamplight. At 9.24 this *H. pictus* ascended for an instant, again at 9.44, and again at 10.1, also for an instant. I stopped observing at 10.11 P.M.

Obs.	Spec.	Minutes of obs.	Ascents.	Seconds at surface.
1.	1	98	2	3
2.	1	100	1	1
3.	1	50	5	6
4.	1	60	1	1
5.	1	60	3	3
	—	—	—	—
Totals	5	368	12	14

Summary.—It appears that this very small species rises once in $30\frac{2}{3}$ minutes, and remains at surface about 3 seconds; and the time it is exposed bears to the time it is concealed a ratio of 1 : 1577. It would seem that it takes in its breath very rapidly; for it was never observed to remain at the surface more than 2 seconds.

VI. HYDROPORUS GYLLENHALLI.

No. 1. October 10th.—Beetle of doubtful sex, concealed when observation commenced, 3.41 P.M. But it rose at 3.59 for 1 second

for aeration; again at 4.34, remaining up for 3 seconds. Ceased watching at 4.41 P.M.

No. 2. By lamplight, same night at 9.14, when the beetle was under cover. It afterwards made the following ascents:—

9.38, up for 32 seconds.	9.55, up for 2 seconds.
9.39 " 2 "	9.55 " 6 "
9.41 " 3 "	9.57 " 2 "
9.44 " 3 "	9.57 " 8 "
9.52 " 2 "	then concealed; obs. ceased
9.53 " 10 "	at 10.14 P.M.

It hid itself between 9.44 and 9.52, but during the other intervals continued active.

Obs.	Spec.	Minutes of obs.	Ascents.	Seconds at surface.
No. 1.	1	60	2	4
" 2.	1	60	10	70
Totals...	2	120	12	74

Summary.—This species was only observed twice; and it appears to be much more active at night than during the day; it rose on the average once in 12 minutes, remaining at surface from 1 to 32 seconds, on an average rather more than 6 seconds on each occasion; and the time it was exposed bears to the time it was concealed a ratio of about 1 : 97 $\frac{1}{4}$.

VII. HYDROPORUS ELEGANS.

No. 1. Oct. 12th.—Kept observation on a male of this species for one hour's duration, viz. between 3.41 P.M. and 4.41 P.M. The beetle was active, and on three occasions during its rapid movements came to the surface of the water, but did not appear to rest there or to take a fresh supply of air.

No. 2. The same night by lamplight.—9.14 P.M. began watch. *H. elegans* was also then active, and rose for the purpose of aeration at 9.49, only remaining up, however, for an instant; again at 9.55 it came to the surface for an instant: 10.14, observation ceased.

Summary.—Only two observations were made on this species, from which it would appear that the species is a very active one, but breathes seldom and very rapidly.

VIII. HYDROPORUS 12-PUSTULATUS.

No. 1. Sept. 12th, 1875.—Observation commenced at 4.5 P.M. The beetle rose at 4.58 P.M. for a short time; it was otherwise

concealed under a stone and quiescent. This observation ceased at 5.45 P.M.

No. 2. Same date.—Observation commenced at 9.19 P.M. by artificial light. At 9.31, was swimming about with great activity, but apparently did not rise for breath; and the same things occurred at 9.40 and at 9.44, but apparently no breathing. Observation ceased at 10 P.M. I am sure the movements were deranged by the light: the specimen was placed in the dark afterwards, and on being visited was seen swimming about, but speedily took refuge; these results were again repeated on a second visit.

This insect is a powerful swimmer; when placed on its back it uses the front legs with a pawing motion, and strikes out with the hind ones, the latter being generally used simultaneously, but occasionally one after the other. It runs on a dry surface rapidly, trailing the hind legs.

No. 3. Sept. 26th.—The same male beetle, concealed; observation continued for one hour, during which the beetle was quite quiescent and never appeared.

No. 4. At night, by lamplight.—At 9.11 P.M. watch begun, when the beetle came out from concealment at the subjoined times, but did not rise.

9.24		9.40		9.50		10. 4
9.35		9.45		9.53		10.10

Further observation ceased at 10.11 P.M. Thus the beetle did not rise to breathe, though it kept coming out from concealment as if to do so; its movements were perhaps disturbed by artificial light.

Summary.—This species is closely allied to *H. elegans*; and it would appear that, like it, it is often very active and breathes very seldom, and very rapidly.

IX. NOTERUS SPARSUS.

No. 1. Sept. 26th.—In this case my observation commenced at 1.31 P.M., beetle concealed at edge of a piece of wood; at 2.23 it crawled up this wood to the surface, breathed for 8 seconds, and returned to its original position. Observation ceased at 2.31 P.M.

No. 2. Resumed watching the same night, with the appended results:—

Rose at :—

9.12 to breathe for an instant.	9.39 to breathe for 17 seconds.
9.14 " " 15 seconds.	9.44 " " 7 "
9.17 " " an instant.	9.47 " " 8 "
9.20 " " 15 seconds.	9.50 " " 15 "
9.25 " " 20 "	9.53 " " 4 "
9.26 " " 8 "	9.57 " " 12 "
9.30 " " 12 "	9.58 " " 12 "
9.30 " " 5 "	10. 4 " " 5 "
9.35 " " 22 "	10.10 " " 15 "

Observation ceased at 10.11 P.M.

During this hour the insect was in constant activity, and glided about in the water in a graceful manner, generally rather slowly, and with a motion similar to that of *Hydrovatus*, the four front legs being used in paddling, probably in combination with the hind tarsi or the hind tibiæ and tarsi, the femora being probably flexed and quiet; it can, on being alarmed, shoot away with great velocity, this probably being accomplished by the use of the hind leg in its entirety.

No. 3. Oct. 17th, 1875.—Observations commenced at 2.1 P.M., beetle not having been fed for two days; beetle buried in mud; rose at 2.13 for 5 seconds to breathe, and again at 2.55 for 5 seconds. Observation ceased at 3.4 P.M., beetle fed at 3.6.

No. 4. Observation resumed at 4.25; beetle rose at

4.27 for 2 seconds to breathe.	4.57 for 3 seconds to breathe.
4.31 " 10 " "	5.21 " 1 second to breathe.
Eating.	5.24 " 5 (P) secs. to breathe.
4.36 for 10 " "	5.24 " 1 second to breathe.

Observation ceased at 5.25.

No. 5. Later on observation recommenced at 9.7 P.M., by lamp-light; beetle appeared at 9.44 for 4 seconds to breathe. Observation ceased at 10.7.

Obs.	Minutes.	Ascents.	Seconds at surface.
No. 1	60	1	8
" 2	60	18	184
" 3	63	2	10
" 4	60	7	32
" 5	60	1	4
Totals ...	303	29	238

Summary.—This species rose to breathe on the average once in $10\frac{1}{2}$ minutes, and remained on an average about $8\frac{1}{5}$ seconds for each respiration, this period varying, however, from 1 second to 22 seconds; the time it was exposed for this purpose bearing to the time it was concealed a ratio of about $1:76\frac{1}{3}$. From one observation it would seem that the species is more active by night, but a second observation contradicted this; on this second occasion the beetle had, however, fed largely a few hours before, and this might possibly account for the discrepancy.

X. LACCOPHILUS OBSCURUS, *Schäum.*

No. 1. Sept. 19th, 1875.—A female example of this beetle was quiescent at 3.36 P.M. near the surface in a tuft of weed, reaching to the surface; at 3.39 it quietly ascended the weed to the surface, and, making a very small crack, remained breathing 80 seconds, then quietly descended to its original position; as it descended, a bubble of air was extended, but not detached, till about 3.48, when it was detached, and the beetle rose to the surface as before, and remained breathing just as before for 60 seconds. The above-mentioned descent then reoccurred; at 4.8 the bubble was detached, and at 4.9 the beetle breathed for 55 seconds, and at 4.33 again for 45 seconds. Except for the slight rises and descents, quite quiescent all the time. Observation ceased at 4.36 P.M.

No. 2. Sept. 20th.—The same specimen examined by artificial light at 8.42 P.M., when the following ascents and other movements were taken cognisance of:—

Rose at:—

8.48 for breathing for 2 secs.	9. 8 for breathing for 2 secs.
8.48 " " 2 "	9. 9 " " 2 "
8.48 " " 15 "	9.13 " " 30 "
8.51 " " 2 "	9.19 " " 102 "
8.59 " " an instant.	9.23 " " 5 "
9. 0 " " 25 secs.	9.28 " " 20 "
9. 5 " " 75 "	9.31 " " 210 "

Observation ceased at 9.42 P.M. The beetle moved about pretty freely in water in a very graceful and perfect manner, having two or three very different motions. In one it undulates slowly through the water (somewhat after the manner of *Hydrovatus*), this being done by paddling with the middle and front legs, while the hind ones are flexed and motionless; a second

faster motion is performed by moving the hind tarsi rapidly (or perhaps the hind tarsi and tibiæ), while the femora are kept flexed on the breast. This motion may be at once changed into a rapid violent shoot forwards, caused no doubt by the femora and the whole of the hind leg being brought into use. When placed on its back out of water it strikes out violently with both hind legs simultaneously; the hopping motion is performed in this way: when walking out of the water, it moves the hind legs alternately.

Obs.	Minutes of observation.	Ascents.	Seconds at surface.
No. 1.	60	4	240
„ 2.	60	14	492
Totals	120	18	732

Summary.—The beetle rose on the average once in $6\frac{2}{3}$ minutes for breathing, and remained on an average $40\frac{2}{3}$ seconds at surface for each respiration. The longest interval observed between two respirations was 20 minutes, and the duration of a respiration varied from 1 second to 210 seconds. The time it was exposed for breathing bore to the time it was concealed a ratio of 1 : $9\frac{5}{6}$. Only two observations were made, one by night; and it is probable that the species is more active by night.

XI. COLYMBETES EXOLETUS.

No. 1. Oct. 17th.—Observation commenced at 2.1 P.M. The insect rose at

2.20 for 40 seconds to breathe.		2.42 for 35 seconds to breathe.
2.29 „ 65 „ „		2.49 „ 55 „ „

At 2.51 it came out of the water and was put back at 2.56; it rose at 2.59 to surface and stayed there 4 minutes. Observation ceased at 3.4.

No. 2. Same afternoon 4.25 P.M.—This ♀ of *C. exoletus* rose for purposes of aeration as follows:—

4.39 for 40 seconds to breathe.		5.11 for 30 seconds to breathe.
4.51 „ 8 „ „		5.20 „ 50 „ „
5. 3 „ 20 „ „		5.25 observation ceased.

No. 3. From 9.7 P.M., by lamplight, the accompanying record of its movements was kept.

Rose at:—

9.18 and remained up 15 seconds.	9.56 and remained up 20 secs.
9.35 " " 75 "	9.57 " " 10 ? "
9.40 " " 25 "	9.59 " " 5 "
9.43 " " 2 mins.	10. 0 at surface.
(breathing doubtful.)	10. 2 " 3 seconds.
9.47 and remained up 15 seconds.	10. 4 at surface.
9.52 " " 3 "	10. 5 at surface.
9.55 " " 30 "	10. 7 observation ceased.

This individual appeared all day to be uncomfortable: it was restless and active, and kept straining the apical segments of its hind body, and discharging bubbles of gas. It was probably desirous of ovipositing; and I have therefore not compared its activity with that of the other species.

XII. ILYBIUS FULIGINOSUS.

No. 1. Aug. 22nd, 1875.—Began observing at noon; up at 12.1½.

Again at 12.2½; then was eating piece of a worm at 12.4.

12.6 remained up 30 seconds.

12.8 came up to surface with a piece of a worm, and remained at the surface eating for about 2 minutes.

12.12 remained up for 25 seconds, eating after descent.

*12.14½, remained up for 18 secs.	12.36 remained up for 38 secs.
*12.15½ " " 25 "	12.37 " " 10 "
12.19 " " 25 "	12.39 " " 20 "
12.22½ " " 23 "	12.42 " " 33 "
12.25 " " 19 "	12.46 " " 35 "
12.28½ " " 25 "	12.50 " " 30 "
*12 32½ " " 25 "	

At 12.50½ it brought up a piece of a worm to the surface, there remaining, eating it and breathing for 7½ minutes. The *Ilybius* again rose at 12.60 and stayed up for 20 seconds. I left off watching at 1.1 P.M. On descending after the hours marked with an asterisk (*), the insect began eating its food. It was observed that after eating, the specimen only reached the surface with difficulty to breathe, it being probable that the space containing air was diminished by the distended alimentary canal, the quantity of worm eaten being large; bubbles of gas were frequently

emitted by the specimen when under water. The same afternoon this specimen, at 3.19, was observed to be suspended at the surface of the water in an absolutely motionless condition, in which condition it continued till 3.59. Owing to its position, it was not for certain ascertained whether any crack for breathing remained open or not. At 3.59 it moved, and the aperture under the elytra was widely opened; and at 3.60 it descended, but speedily came up again and resumed its former motionless position at the surface, which it retained for nearly half an hour; during this half-hour its position was such that it could be observed with a magnifying lens; this was done several times, and a small breathing-aperture was always observed to be present.

Only a single observation was made on this species, and during that observation the insect was feeding. This beetle remained for long periods suspended at the surface of the water: it was in this exposed position on one occasion for 40 minutes without moving.

XIII. AGABUS BIPUSTULATUS.

No. 1. Aug. 26th, 1875.—A female specimen observed from 1.51 P.M. till 2.31 P.M. Between these times it rose for purposes of aeration at

1.54, remaining up 8 secs.		2.18, remaining up 8 secs.
2. 6 " 55 "		2.25 " 35 "

No. 2. Sept. 5th.—The same insect again kept close scrutiny upon; and the accompanying notes show the intervals of its appearance at the surface:—

3.22, observation commenced.		4.21, remained up 65 secs.
3.24, remained up 45 secs.		4.34 " 22 "
3.35 " 30 "		4.38 " 17 "
3.43 " 12 "		4.47 " 37 "
3.55 " 21 "		5. 1 " 15 "
4. 6 " 10 "		5. 2, observation ceased.

The insect buried itself in the mud so that it could not be seen; this it only left for breathing, and descended immediately, except in the case of the small interval 4.34–4.38, when it moved about the bottom instead of concealing itself. The elytra are held very wide open for breathing.

No. 3. The *A. bipustulatus* was again watched at night, and its movements recorded, thus:—

7.42 P.M. observation commenced.

7.48 at surface for 25 secs.		8.22 at surface for 70 secs.
8. 0 " 23 "		8.37 " 20 "
8.12 " 77 "		8.42 ceased observing.

This observation was made after dark by light of a lamp; the beetle comported itself exactly as in the previous observation made in daylight.

No. 4. Oct. 17th.—The beetle in this instance was fasting; observation commenced at 2.1 P.M. It rose at 2.12 for 25 seconds to breathe, and again at 2.49 for 75 seconds. It otherwise was concealed in the mud. Observation ceased at 3.4 P.M. The beetle was fed at 3.6 P.M.

No. 5. Observation resumed at 4.25; beetle rose at 4.35 for 24 seconds to breathe; again at 4.45 for 95 seconds; and again at 5.6, remaining at the surface 150 seconds. The observation ceased at 5.25.

No. 6. Still later at night, 9.7 P.M., and by artificial light, investigation was renewed. The insect rose to draw in air at

9.14, and up for 15 secs.		9.47, and up for 15 secs.
9.26 " 80 "		9.59 " 15 "
9.36 " 120 "		10. 7 left off inspection.

The six preceding observations may be thus reduced:—

Obs.	Minutes obs.	Ascents.	Seconds at surface.
No. 1.	40	4	106
" 2.	100	10	274
" 3.	60	5	215
" 4.	63	2	100
" 5.	60	3	269
" 6.	60	5	245
Totals.....	383	29	1209

Summary.—The beetle rose, on an average, about once in $13\frac{1}{3}$ minutes for breathing, and remained, on an average, about $41\frac{2}{3}$ seconds at surface for each respiration. The longest interval observed between two respirations was 37 minutes; but this was an exceptionally long interval. The duration of a respiration

varied from 8 seconds to 150 seconds. The time it was exposed for breathing bore to the time it was not so exposed a ratio of $1:19\frac{1}{10}$. The species was observed twice at night, but appeared to be scarcely more active than during the day.

XIV. ACILIUS SULCATUS, var.

No. 1. Sept. 19th, 1875.—A female specimen, rather immature, fasting. Observation commenced at 3.36 P.M.

3.42, breathed for an instant.	4.15, breathed for an instant.
3.46 " " " "	4.17 " " " "
3.48 " " 20 seconds.	4.18 " " " "
3.54 " " an instant.	4.20 " " " "
3.57 " " " "	4.22 " " 50 seconds.
4. 1 " " " "	4.24 " " 25 "
4. 4 " " " "	4.27 " " 27 "
4. 7 " " " "	4.30 " " 20 "
4.10 " " " "	4.33 " " 20 "
4.14 " " " "	

Observation ceased at 4.36. The instantaneous breathings were performed by rising to the surface, opening wide the breathing-crack and instantly descending; bubbles of gas escaping from the extremity during descent.

No. 2. Sept. 20th.—By lamplight; observation commenced at 8.42 P.M., when the following times of ascent for aeration were observed:—

8.46, breathing an instant.	9.16, breathing 5 secs.
8.48 " " " "	9.17 " 15 "
8.53 " " " "	9.20 " 17 "
8.55 " " " "	9.22 " 10 "
8.58 " " " "	9.25 " 30 "
8.59 " " " "	9.26 " 15 "
9. 0 " " " "	9.30 " an instant.
9. 1 " 45 secs.	9.31 " 40 secs.
9. 4 " 15 "	9.37 " 30 "
9. 5 " 25 "	9.39 " 20 "
9. 7 " 15 "	9.40 " 20 "
9.10 " 20 "	9.42, observation ceased.
9.13 " 22 "	

The beetle was not improbably disconcerted by the artificial light. It occasionally progressed slowly by paddling with the middle legs, the hind ones being extended, but almost motionless.

Obs.	Minutes of observation.	Ascents.	Seconds at surface.
No. 1.	60	19	175
„ 2.	60	24	352
Totals ...	120	43	527

Summary.—The beetle rose, on an average, about once in $2\frac{3}{4}$ minutes for breathing, and remained, on an average, about $12\frac{1}{4}$ seconds at surface for each respiration. The longest interval observed between two respirations was 6 minutes; the duration of a respiration varied from a second, or less, to 50 seconds. The time it was exposed for breathing bore to the time it was not so exposed a ratio of $1 : 13\frac{2}{3}$. Only two observations were made, one of them at night, and it was then rather more active than during the day-observation.

XV. ACILIUS FASCIATUS.

No. 1. Oct. 17th.—The two specimens, ♂ and ♀, herein mentioned, were not fed for two days. My observations commenced at 2.1 P.M. At 2.46 the male rose, and was at the surface for 5 seconds; whilst the female emerged at 2.49, remaining up for 65 seconds. These beetles moved about but little, keeping themselves much concealed. I left off further notice at 3.1 P.M.

No. 2. The specimens were fed at 3.6 P.M., and observation commenced at 4.25.

The male.		The female.	
Rose at 4.43 for	70 secs.	Rose at 5.17 for	55 secs.
„ 5. 5 „ 100 „		„ 5.20 „ 30 „	

The beetles were nearly always concealed, and moved about but little. Observation ceased at 5.25.

No. 3. By lamplight, same evening. Observation commenced at 9.7.

The male.	The female.
Rose at 9.21 for 4 minutes, but only occasionally breathing.	Rose at 9.37 for 35 secs.
Rose at 9.35 for 15 secs.	„ 9.57 „ 35 „
„ 9.40 „ 100 „	Observation ceased at 10.37.
„ 9.53 „ 65 „	
„ 10. 0 „ 50 „	
„ 10. 5 „ 105 „	

Obs.	Minutes of observation.	Ascents.	Seconds at surface.
No. 1.	120	2	70
„ 2.	120	4	255
„ 3.	120	8	645
Totals	360	14	970

Summary.—The species rose, on an average, about once in 25 $\frac{3}{4}$ minutes for breathing, and remained, on an average, nearly 70 seconds at surface for each respiration. The longest interval observed between two respirations was 52 minutes, and the duration of a respiration varied from 5 to 105 seconds. The time it was exposed for breathing bore to the time it was not so exposed a ratio of 1 : 22 $\frac{1}{4}$. It appears probable that the species is more active by night than by day, and that the male is more active than the female.

XVI. DYTISCUS MARGINALIS.

No. 1. Aug. 2nd, 1874.—Observation commenced at 7 o'clock P.M. on one ♂ individual of this species.

Rose at 7. 9 for ? secs.	Rose at 7.56 for 70 secs.
„ 7.16 „ 45 „	„ 8. 2 „ 40 „
„ 7.22 „ 85 „	„ 8. 9 „ an instant.
„ 7.36 „ 115 „	„ 8. 9 „ 30 secs.
„ 7.45 „ 15 „	„ 8.15 „ 300 „
„ 7.50 „ 50 „	„ 8.22 „ 65 „

Observation ceased at 8.23 P.M.

No. 2. Aug. 9th, 1874.—Observation commenced at 3.40 P.M., on two males of *D. marginalis*.

Rose at 3.48 for 15 secs.	Rose at 4.22 for 50 secs.
„ 3.48 „ 20 „	„ 4.22 „ 60 „
„ 3.51 „ 5 „	„ 4.24 „ 5 „

Rose at 3.53 for 35 secs.	Rose at 4.27 for 30 secs.
„ 3.56 „ 40 „	„ 4.29 „ 25 „
„ 3.59 „ 45 „	„ 4.31 „ 120 „
„ 4. 3 „ 20 „	„ 4.34 „ an instant.
„ 4. 4 „ 20 „	„ 4.35 „ 115 secs.
„ 4.12 „ 45 „	„ 4.40 „ 140 „
„ 4.12 „ 90 „	

Observation ceased at 4.43 P.M.

No. 3. Aug. 9, 1874.—Observation commenced at 2.31 P.M. on one ♂ *D. marginalis*.

Rose at 2.50 for 2 secs.	Rose at 3.26 for 5 secs.
„ 2.56 „ 35 „	„ 3.38 „ 97 „
„ 3. 9 „ 60 „	„ 3.57 „ 97 „

Observation ceased at 4.11 P.M.

Obs.	Minutes of observation.	Ascents.	Seconds at surface.
No. 1	83	12	816
„ 2	126	19	881
„ 3	100	6	296
Totals . . .	309	37	1993

Summary.—The male of *D. marginalis* rose, on an average, once in about $8\frac{1}{2}$ minutes for breathing; and remained, on an average, about 54 seconds at surface for each respiration. The longest interval it was observed to pass without breathing was 19 minutes. The duration of a respiration varied from 5 seconds to 300 seconds; and the time it was exposed bore to the time it was quiescent a ratio of 1:9 $\frac{1}{2}$.

XVII. DYTISCUS MARGINALIS, ♀.

No. 1. Aug. 2nd, 1874.—Observation commenced at 7 P.M. on one female.

Rose at 7. 8 for 20 secs.	Rose at 7.50 for an instant.
„ 7.22 „ 80 „	„ 7.54 „ 80 secs.
„ 7.38 „ 100 „	„ 8.15 „ 280 „

Observation ceased at 8.23 P.M.

No. 2. Aug. 9th, 1874.—Observation commenced at 3.40 P.M. on two females of *D. marginalis* :—

Rose at 3.51 for 5 secs.	Rose at 4.12 for 50 secs.
„ 3.55 „ an instant.	„ 4.23 „ 90 „
„ 3.59 „ „	„ 4.28 „ an instant.
„ 3.59 „ 65 secs.	„ 4.29 „ 15 secs.
„ 3.60 „ 25 „	„ 4.33 „ 70 „
„ 4. 3 „ an instant.	„ 4.35 „ 110 „
„ 4. 4 „ 80 secs.	„ 4.39 „ 70 „

Observation ceased at 4.43 P.M.

No. 3. Aug. ?, 1874.—Observation commenced on one individual of *D. marginalis*, ♀, at 2.31 P.M.

Rose at 2.56 for 35 secs.	Rose at 3.42 for 3 secs.
„ 3. 8 „ 90 „	„ 3.46 „ 65 „

Observation ceased at 4.11.

Obs.	Minutes of observation.	Ascents.	Seconds at surface.
No. 1. . . .	83	6	561
„ 2. . . .	126	14	584
„ 3. . . .	100	4	193
Totals . . .	309	24	1338

Summary.—The female of *D. marginalis*, rose, on the average, once in about $12\frac{7}{8}$ minutes for breathing, and remained, on an average, about $55\frac{1}{2}$ seconds at surface for each respiration. The longest interval it was observed to pass without breathing was $32\frac{1}{2}$ minutes. The duration of a respiration was from 3 seconds to 280 seconds. And the time it was exposed bore to the time it was quiescent a ratio of $1:13\frac{4}{5}$.

On *Actæomorpha erosa*, a new Genus and Species of Crustacea.
By EDWARD J. MIERS, F.L.S., Assistant in the Zoological Department, British Museum.

[Read December 21, 1876.]

(PLATE XIV.)

THE remarkable Crustacean here described was brought up by the dredge from a depth of 7 fathoms with a number of other small Crustacea, chiefly *Cancroidea*. On account of its small size and external resemblance to certain species of *Canceridæ*, its true posi-